Starter of single-phase induction motor

TECHNICAL FIELD

The present invention relates to a starter of a single-phase induction motor, such as a compressor motor for refrigerator (enclosed motor compressor) or a pump motor.

BACKGROUND ART

Starters are often used in single-phase induction motors for driving, for example, refrigerator, air conditioner, and other enclosed compressor. This kind of starter is shown in Fig. 27 (A), positive characteristic thermistor 312 is connected in series to an auxiliary winding S energized by alternating-current power source 90 along with main winding M connected parallel with respect to auxiliary winding S. In such a starter, when starting up single-phase induction motor 100, positive characteristic thermistor 312 presents a low electrical resistance, and a starting current flows in auxiliary winding S. By the starting current, positive characteristic thermistor 312 becomes high in resistance, and the current to auxiliary winding S is limited. In this configuration, during stationary operation after completion of starting of the single-phase induction motor, positive characteristic thermistor 312 is applied with supply voltage and continues to generate heat by itself, and power of about 2 to 4 W is always wasted.

Further, in the conventional starter, right after stopping of single-phase induction motor 100, re-starting was difficult. That is because, positive characteristic thermistor 312 for starting is large in thermal capacity, once reaching high temperature and high resistance during operation, it takes dozens of seconds to several minutes until it is ready to start again.

If attempted to start again before this lag time, since positive characteristic thermistor 312 is high in resistance due to the undepleted heat, only small current flows in auxiliary winding S. Therefore, the rotor of motor 100 is confined. In the meantime, a large current flows through main winding M, and overload relay 50 is actuated to arrest the re-starting. The reset time of the overload relay is initially slightly shorter than the cooling period of positive characteristic thermistor 312 to be ready to re-start. If the overload relay operates and resets repeatedly, the temperature becomes higher gradually, and the reset time is longer. As the reset time of the overload relay becomes longer than the cooling period of positive characteristic thermistor 312, motor 100 is ready to start. A similar phenomenon occurs in a compressor motor for refrigerator, that is, when the compartment temperature drops, the thermostat is cut off, and the compressor motor stops; immediately when the door is opened, the compartment temperature rises, and the thermostat is turned on. In such a case, not only it takes longer time for re-starting, the life of the overload relay is also shortened.

Accordingly, the present applicant previously proposed a starter for single-phase induction motor having the structure as shown in Fig. 27 (B), by fling a patent in Japanese unexamined patent publication No. H6-38467. In the circuit, bimetal 218 is provided in series to positive characteristic thermistor 312 in starter 210. By heating bimetal 218, current to the positive characteristic thermistor 312 is cut off. By resistance 214 of smaller power consumption than positive characteristic thermistor 312, the OFF state of bimetal 218 is maintained, and power consumption is reduced. Further, Japanese unexamined utility model publication No. S56-38276 discloses a starter having positive characteristic thermistor disposed in two divisions.

Further, in the starter having positive characteristic

thermistor, for the ease of mounting the single-phase induction motor, socket terminals may be provided to be connected to the connection pins provided at the side of the single-phase induction motor. For example, as disclosed in Japanese unexamined utility model publication No. S62-115760, three connection pins project from the single-phase induction motor, and they are electrically connected by way of socket terminals on the starter.

Electrical devices receive very larger vibrations from the motor and others. Therefore, if the holding strength of socket terminals is weak, when dismounting for checking, or when reassembling after removal the electric contact of the starter with the electrical devices may be insufficient. In particular, in a starter for staring a large motor, the contact area is heated and terminal can be damaged. The starter may not function in these cases. Further, there is possibility of fire or other accident.

A plan view of socket terminal incorporated in a conventional starter of prior art is shown in Fig. 28 (A), a sectional view in Fig. 28 (B), and a bottom view in Fig. 28 (C). This socket terminal 122 is connected to connection pin 212 as shown in Fig. 28 (F). In this arrangement, the stress by galling (galling force) mainly occurs in two directions X and Y. As a result, socket terminal 122A may not restore the original position due to effects of galling force as shown in Fig. 28 (G). Hence, the gripping force of connection pin 212 by socket terminal 122A is substantially lowered, and the contact resistance increases due to faulty contacts. When current flows, heat is generated, and damage of terminal and other problems may occur.

To solve these problems, various patents have been proposed, such as Japanese unexamined patent publication No. H8-149770, and Japanese unexamined patent publication No. 2001-332159. Japanese unexamined patent publication No. H8-149770 proposes a tubular socket terminal having four grooves provided along the

inserting and removing direction of the connection pin. Japanese unexamined patent publication No. H8-149770 also proposes a pair of junction tongues for absorbing stress if galling force occurs in the gripping portion. Japanese unexamined patent publication No. 2001-332159 proposes a bump for preventing the socket terminal from opening near the slit opening of the socket terminal.

However, in the starter disclosed in Japanese unexamined patent publication No. H6-38467, in order to maintain the OFF state of bimetal 218 by resistance 214, as compared with the circuit configuration in Fig. 27 (A), the power consumption was reduced to 1/3. In Japanese unexamined utility model publication No. S56-38276, since the positive characteristic thermistor is divided into two sections, the power consumption can be reduced by half.

In addition to the power consumption, in the starter of Japanese unexamined patent publication No. H6-38467, since the thermal capacity is large in resistance 214 for maintaining the OFF state of bimetal 218, the single-phase induction motor could not be re-started quickly. In Japanese unexamined utility model publication No. S56-38276, since the positive characteristic thermistor is divided into two sections, the re-starting time could be decreased only to half.

The invention is devised to solve the problems of the prior art, and it is hence an object thereof to present a starter for single-phase induction motor capable of saving energy by substantially reducing consumption of power during stationary operation by using positive characteristic thermistor for starting.

The tubular socket terminal disclosed in Japanese unexamined patent publication No. H8-149770 is likely to be deformed by the stress on the arc portion divided by a groove. The socket terminal having the junction tongues of Japanese unexamined patent publication No. H8-149770 has the junction

tongues projecting sideways, it takes a lot of space and therefore, it is hard to store into the starter. The socket in Japanese unexamined patent publication No. 2001-332159 has a bump formed separately from the socket terminal, it also takes a lot of space and is hard to store into the starter.

The invention is designed to solve these problems, and it is hence a still further object to present a starter of high reliability and long durability.

DISCLOSURE OF THE INVENTION

In order to achieve the above objects, according to embodiment 1, a starter of single-phase induction motor having main winding and auxiliary winding energized by alternating-current power source, comprising:

a casing,

a positive characteristic thermistor connected in series to the auxiliary winding,

an auxiliary positive characteristic thermistor connected parallel to the positive characteristic thermistor and a snap action bimetal,

the snap action bimetal connected in series to a series circuit of auxiliary winding and positive characteristic thermistor for sensing the heat from the auxiliary positive characteristic thermistor and turning off when reaching a set temperature, and

an enclosed compartment accommodated in the casing, for enclosing the snap action bimetal and auxiliary positive characteristic thermistor.

In order to achieve the above objects, according to embodiment 5, a starter of single-phase induction motor having main winding and auxiliary winding energized by

alternating-current power source, comprising:

a casing,

a positive characteristic thermistor connected in series to the auxiliary winding,

an auxiliary positive characteristic thermistor connected parallel to the positive characteristic thermistor and a snap action bimetal,

the bimetal connected in series to a series circuit of auxiliary winding and positive characteristic thermistor for sensing the heat from the auxiliary positive characteristic thermistor and turning off when reaching a set temperature,

an enclosed compartment accommodated in the casing, for enclosing the bimetal and auxiliary positive characteristic thermistor, and

a magnet for applying magnetic force to the bimetal so as to force the contact point to the ON side.

According to embodiment 7, a starter of single-phase induction motor having main winding and auxiliary winding energized by alternating-current power source, comprising:

a casing,

a positive characteristic thermistor connected in series to the auxiliary winding,

an auxiliary positive characteristic thermistor connected parallel to the positive characteristic thermistor and a snap action bimetal,

a temperature sensing magnet for sensing the heat from the auxiliary positive characteristic thermistor and demagnetizing when reaching a set temperature,

a switch connected in series to a series circuit of auxiliary winding and positive characteristic thermistor, and turning on as being attracted by the magnetic force of the

temperature sensing magnet, and turning off by demagnetization of the temperature sensing magnet, and

an enclosed compartment accommodated in the casing, for enclosing the switch.

According to embodiment 8, a starter of single-phase induction motor having main winding and auxiliary winding energized by alternating-current power source, comprising:

a positive characteristic thermistor connected in series to the auxiliary winding,

an auxiliary positive characteristic thermistor connected parallel to the positive characteristic thermistor and a snap action bimetal,

a temperature sensing magnet for sensing the heat from the auxiliary positive characteristic thermistor and demagnetizing when reaching a set temperature, and

a reed switch connected in series to a series circuit of auxiliary winding and positive characteristic thermistor, and turning on as being attracted by the magnetic force of the temperature sensing magnet, and turning off by demagnetization of the temperature sensing magnet.

In the starter for single-phase induction motor as set forth in embodiment 1 of the invention, when starting up the single-phase induction motor, since the positive characteristic thermistor is low in resistance, a starting current flows through the auxiliary winding by way of a series circuit of positive characteristic thermistor and snap action bimetal, and the single-phase induction motor is started up. By flow of starting current, the positive characteristic thermistor generates heat by itself, and becomes high in resistance, and more current flows into the auxiliary positive characteristic thermistor side

connected parallel to the positive characteristic thermistor. When the auxiliary positive characteristic thermistor reaches a set temperature, the snap action bimetal is cut off, and no current flows into the positive characteristic thermistor, and the single-phase induction motor starts up completely, and gets into stationary operation.

When the snap action bimetal is cut off, current flows only into the auxiliary positive characteristic thermistor side to generate heat, and by this heat generation, the snap action bimetal is kept in OFF state.

Therefore, during stationary operation of single-phase induction motor, no current flows into the positive characteristic thermistor and instead current flows into the auxiliary positive characteristic thermistor side, but the current flowing in the auxiliary positive characteristic thermistor is very small only enough to generate heat in the auxiliary positive characteristic thermistor for holding the OFF state of the snap action bimetal, and power consumption by the auxiliary positive characteristic thermistor is extremely smaller than the power consumption by the conventional positive characteristic thermistor.

In particular, since the snap action bimetal and auxiliary positive characteristic thermistor are contained in a same enclosed compartment in the casing, heat hardly radiates outside, and the OFF state of the snap action bimetal can be maintained by a very small power consumption. Further, as the refrigerant of enclosed compressor, flammable gas (hydrocarbon compound such as butane) is used, and if the refrigerant leaks, it is contained within the enclosed compartment, ignition by spark in opening

and closing action of snap action bimetal is prevented.

Further, during stationary operation of single-phase induction motor, the positive characteristic thermistor for starting in large thermal capacity is cooled, and temperature is ordinary. On the other hand, since the auxiliary positive characteristic thermistor is small in thermal capacity, it is quick to cool. Therefore, when attempted to start up again right after stopping the single-phase induction motor, the auxiliary positive characteristic thermistor is immediately cooled nearly to ordinary temperature, and it is ready to start up very quickly in several seconds to dozens of seconds, and it is possible to re-start quickly without repetition of operation and reset of overload relay as in the prior art.

Moreover, a small-sized auxiliary positive characteristic thermistor is used for heating the bimetal, it is effective for correcting changes in response to ambient temperature, without the disadvantages of voltage fluctuations.

According to embodiment 2, the starter of single-phase induction motor, wherein the snap action bimetal is composed of a movable contact plate for oscillating a movable contact point, a bimetal, and a plate spring of semicircular section interposed between first support point of the movable contact plate and second support point of the bimetal,

the movable contact plate is forced so as to cause the plate spring to push the movable contact point to the fixed contact point side when the second support point is shifted to the leading end position side at low temperature of the bimetal, and

the movable contact plate is forced so as to cause the plate spring to depart the movable contact point from the fixed contact point side when the second support point is shifted to the leading

end position side at high temperature of the bimetal. Accordingly, the snap action bimetal can cut off the contact quickly. Therefore, the arc does not continue, and the rough contact or noise does not occur. Connection time after contact pressure becomes zero, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and durable.

In embodiment 3, the starter of single-phase induction motor, wherein the snap action bimetal is a bimetal processed by drawing. In embodiment 4, the starter of single-phase induction motor, wherein the snap action bimetal is a bimetal processed by forming in a circular form in the center. Accordingly, the snap action bimetal can cut off the contact quickly. Therefore, the arc does not continue, and the rough contact or noise does not occur. Connection time after contact pressure becomes zero is short, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and durable.

In embodiment 5, the bimetal having contact at free end side is forced to the contact ON side by the magnetic force of the magnet. When the bimetal is cut off, the magnetic force from the magnet is lowered inversely proportional to the square of the distance. The bimetal receives the strongest magnetic force in contact ON state, and after the contact leaves, the magnetic force decreases rapidly, so that the contact can be cut off quickly. Therefore, the arc does not continue, and the rough contact or noise does not occur. Connection time after contact pressure becoming becomes zero, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and durable.

In embodiment 6, an auxiliary positive characteristic thermistor contacts with the base of the bimetal. Hence, heat

from the auxiliary positive characteristic thermistor can be efficiently transmitted to the bimetal, and the OFF state of the bimetal can be maintained by the auxiliary positive characteristic thermistor of small power consumption.

In embodiment 7, for example, a switch having a contact at free end side of spring plate made of magnetic conductive member senses heat from the auxiliary positive characteristic thermistor. When the temperature reaches the set temperature, it is forced by the magnetic force of the temperature sensing magnet which is demagnetized. That is, at less than the set temperature, the switch resists the elastic force of the spring plate, and is attracted by the magnetic force of temperature sensing magnet, and is turned on, and when exceeding the set temperature, the switch is turned off by the elastic force of spring plate by demagnetization of the temperature sensing magnet. At this time of turning off, the magnetic force from the temperature sensing magnet drops inversely proportional to the square of the distance. The switch has the strongest magnetic force in contact ON state, and after the contact leaves, the magnetic force drops rapidly, so that the contact can be cut off quickly. Therefore, the arc does not continue, and the rough contact or noise does not occur. Connection time after contact pressure becomes zero, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and durable.

In embodiment 8, a reed switch senses the heat from the auxiliary positive characteristic thermistor, it is turned on or off by the magnetic force of temperature sensing magnet which is demagnetized when reaching the set temperature. At lower than the set temperature, the reed switch is turned on by the magnetic force of temperature sensing magnet, and when exceeding the set

temperature, the reed switch is turned off by demagnetization of the temperature sensing magnet. At this time of turning off, the magnetic force from the temperature sensing magnet drops inversely proportional to the square of the distance, and the reed switch is cut off quickly. Therefore, the arc does not continue, and the rough contact or noise does not occur. Connection time after contact pressure becoming zero is short, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high, and it is free from defect for a long period of time.

In embodiment 9, the starter of single-phase induction motor, wherein a through-hole is pierced in a specified position of a conductor plate having a spring member for connecting electrically while holding the positive characteristic thermistor by elastic force, and a fuse is provided by narrowing the width in the outer circumference of the through-hole. Hence, in the event of abnormal heat generation of positive characteristic thermistor, thermal runaway, or elevation of resistance to cause nearly short-circuited state to increase current, the fuse melts down. Hence, burning starting winding or starting relay can be prevented.

In embodiment 10, slots are provided in the contacting corners bent at obtuse angle for contacting with positive characteristic thermistor in the spring section for holding the positive characteristic thermistor. As a result, contact points with positive characteristic thermistor of contacting corners are divided and doubled in number, so that the contact reliability can be enhanced.

In embodiment 11, notches are provided in the contacting corners bent at obtuse angle for contacting with positive

characteristic thermistor in the spring section for holding the positive characteristic thermistor. As a result, contact points with positive characteristic thermistor of contacting corners are divided and doubled in number, so that the contact reliability can be enhanced. Further, the resonance frequency of contacting corners is different between the inside and outside of the notch. Compressor vibration is transmitted to the starter, and the positive characteristic thermistor and spring member resonance, and if the positive characteristic thermistor electrode is hit by spring member, the electrode may damaged or separated, but in embodiment 11, since the resonance frequency is different between the inside and outside of contacting corners, they do not resonate at the same time, and the contacting corners will not hit the positive characteristic thermistor, and electrodes of positive characteristic thermistor will not be damaged.

In order to achieve the above objects, according to embodiment 12, a starter of single-phase induction motor having main winding and auxiliary winding, comprising a positive characteristic thermistor connected in series to the auxiliary winding, and a socket terminal for connecting electrically with a detachable connection pin,

wherein the socket terminal has a pair of plates extending sideways in the axial direction of connection pin bent to the inner side, has the leading end formed in an arc shape so as to conform to the columnar shape of the connection pin, and is provided with a connection pin holder having the leading ends spaced from each other, and

the connection pin holder is divided into two sections by the slit in the connection pin axial direction and vertical direction, into leading end side first position, and inner side second position.

In the starter of embodiment 12, since the connection pin holder of the socket terminal is divided into two sections, first portion at leading end side and second portion at inner side, and if galling force acts when inserting the connection pin, spreading is limited to the first portion at leading end side and spreading is not extended to the second portion at inner side. In the second portion, hence, fatigue is prevented, and favorable contact state with connection pin is maintained, and damage by heating of contact portion does not occur.

Further, when inserting into the connection pin, the first portion at the leading end side is spread and inserted, and when the connection pin leading end reaches the second portion, the second portion begins to spread. That is, the force required for inserting is strongest at the beginning and then remains nearly unchanged in order to push open the portion narrower than the connection pin, but in the invention, it is enough to push open only the first portion at the leading end side being divided, at the initial time of inserting the connection pin, and as compared with the conventional product required to push open the entire connection pin holder, the inserting process is easier. Since the size is same as in the conventional product, the space efficiency is high, and it is easy to apply in the existing starter.

If there is inclination between the connection pin and socket terminal, since the first portion at the leading end and the second portion at the inner side independently contact with the connection pin, if the connection pin and socket terminal contact with each other point to point, the contact point is doubled in number, and the electric connection of connection pin and socket terminal can be assured.

In embodiment 13, since the recess of accommodating the

leading end of the connection pin penetrating through the connection pin holder is provided in the casing, the chamfered portion of the leading end of the connection pin penetrates through the connection pin holder and is positioned in the recess. That is, the since the chamfered portion is not held by the connection pin holder, the gripping force of the connection pin by the connection pin holder can be enhanced, and it is also effective to lower the contact resistance.

In embodiment 14, since the first portion at the leading end side of the connection pin holder is formed wider so as to hold the connection pin more moderately than the inner side second portion, and only a small effort is needed when inserting to insert the connection pin. On the other hand, the inner side second portion is formed narrowly, and a favorable contact state with the connection pin can be held at the second portion, so that damage by heating in the contact portion does not occur.

In embodiment 15, since the length of the connection pin holder in the connection pin axial direction of the first portion at leading end is formed longer than the inner side second portion, the galling force when inserting the connection pin is held in the first portion, and spreading of galling to the second portion is arrested. As a result, favorable contact state with the connection pin can be maintained in the second portion, and damage due o heating of connection portion does not occur.

In embodiment 16, since the length of the connection pin holder in the connection pin axial direction of the second portion at the inner side is formed longer than the leading end first portion at the inner side, by firmly holding the connection pin at the second portion, fatigue is prevented, and favorable contact state with the connection pin is maintained, and damage

by heating of contact portion does not occur.

In embodiment 17, since V-notch is provided at the leading end of the second portion at the inner side of the connection pin holder, when inserting into the connection pin, if the connection pin leading end reaches the second potion after inserting into the first portion of the leading end side, it can be easily inserted into the second portion side, and the inserting work is easy.

In order to achieve the above objects, according to embodiment 19, a starter of single-phase induction motor having main winding and auxiliary winding energized by alternating-current power source, comprising:

a casing,

a positive characteristic thermistor connected in series to the auxiliary winding,

an auxiliary positive characteristic thermistor connected parallel to the positive characteristic thermistor and a snap action bimetal,

a slow action bimetal connected in series to a series circuit of auxiliary winding and positive characteristic thermistor for sensing the heat from the auxiliary positive characteristic thermistor and turning off when reaching a set temperature, and

an enclosed compartment accommodated in the casing, for enclosing the slow action bimetal and auxiliary positive characteristic thermistor.

In the starter of single-phase induction motor as set forth in embodiment 19, when starting up the single-phase induction motor, the positive characteristic thermistor is low in resistance, and a starting current flows through the auxiliary

winding by way of series circuit of positive characteristic thermistor and slow action bimetal, and the single-phase induction motor is started up. When the starting current flows, the positive characteristic thermistor generates heat by itself, and becomes high in resistance, and more current flows into the auxiliary positive characteristic thermistor side connected parallel to the positive characteristic thermistor. When the auxiliary positive characteristic thermistor reaches a set temperature, the slow action bimetal is cut off, and no current flows into the positive characteristic thermistor, and the single-phase induction motor is started up completely and gets into stationary operation.

When the slow action bimetal is cut off, current flows only into the auxiliary positive characteristic thermistor side to generate heat, and by this heat generation, the slow action bimetal is kept in OFF state.

Therefore, during stationary operation of single-phase induction motor, no current flows into the positive characteristic thermistor and instead current flows into the auxiliary positive characteristic thermistor side, but the current flowing in the auxiliary positive characteristic thermistor is very small only enough to generate heat in the auxiliary positive characteristic thermistor for holding the OFF state of the slow action bimetal, and power consumption by the auxiliary positive characteristic thermistor is extremely smaller than the power consumption by the conventional positive characteristic thermistor.

In particular, since the slow action bimetal and auxiliary positive characteristic thermistor are contained in a same enclosed compartment in the casing, heat hardly radiates outside,

and the OFF state of the slow action bimetal can be maintained by a very small power consumption. Further, as the refrigerant of enclosed compressor, flammable gas (hydrocarbon compound such as butane) is used, and if the refrigerant leaks, it is contained within the enclosed compartment, ignition by spark in opening and closing action of slow action bimetal is prevented.

Further, since slow action bimetal is used, as compared with the formed snap action bimetal, it withstands use for a longer period of time.

Further, during stationary operation of single-phase induction motor, the positive characteristic thermistor for starting in large thermal capacity is cooled, and temperature is ordinary. On the other hand, since the auxiliary positive characteristic thermistor is small in thermal capacity, it is quick to cool. Therefore, when attempted to start up again right after stopping the single-phase induction motor, the auxiliary positive characteristic thermistor is immediately cooled nearly to ordinary temperature, and it is ready to start up very quickly in several seconds to dozens of seconds, and it is possible to re-start quickly without repetition of operation and reset of overload relay as in the prior art.

In embodiment 20, an auxiliary positive characteristic thermistor contacts with the base of the slow action bimetal. Hence, the heat from the auxiliary positive characteristic thermistor can be efficiently transmitted to the slow action bimetal, and the OFF state of the slow action bimetal can be maintained by the auxiliary positive characteristic thermistor of small power consumption.

In order to achieve the above objects, according to

embodiment 21, a starter of single-phase induction motor having main winding and auxiliary winding energized by alternating-current power source, comprising:

a positive characteristic thermistor connected in series to the auxiliary winding,

an auxiliary positive characteristic thermistor connected parallel to the positive characteristic thermistor and a snap action bimetal,

a slow action bimetal connected in series to a series circuit of auxiliary winding and positive characteristic thermistor for sensing the heat from the auxiliary positive characteristic thermistor and turning off when reaching a set temperature, and

the snap action bimetal connected in series to a series circuit of auxiliary winding, positive characteristic thermistor, and slow action bimetal for sensing the heat from the positive characteristic thermistor and turning off when reaching a specified high temperature.

In the starter of single-phase induction motor as set forth in embodiment 21, when starting up the single-phase induction motor, the positive characteristic thermistor is low in resistance, and a starting current flows through the auxiliary winding by way of series circuit of positive characteristic thermistor and slow action bimetal, and the single-phase induction motor is started up. When the starting current flows, the positive characteristic thermistor generates heat by itself, and becomes high in resistance, and more current flows into the auxiliary positive characteristic thermistor side connected parallel to the positive characteristic thermistor. When the auxiliary positive characteristic thermistor reaches a set temperature, the slow action bimetal is cut off, and no current flows into the positive characteristic thermistor, and the

single-phase induction motor completes starting-up and gets into stationary operation.

When the slow action bimetal is cut off, current flows only into the auxiliary positive characteristic thermistor side to generate heat, and by this heat generation, the slow action bimetal is kept in OFF state.

Therefore, during stationary operation of single-phase induction motor, no current flows into the positive characteristic thermistor and instead current flows into the auxiliary positive characteristic thermistor side, but the current flowing in the auxiliary positive characteristic thermistor is very small only enough to generate heat in the auxiliary positive characteristic thermistor for holding the OFF state of the slow action bimetal, and power consumption by the auxiliary positive characteristic thermistor is extremely smaller than the power consumption by the conventional positive characteristic thermistor. Further, since slow action bimetal is used, as compared with the formed snap action bimetal, it withstands use for a longer period of time.

When the positive characteristic thermistor generates heat abnormally and reaches given high temperature, the snap action bimetal is cut off, and current to the auxiliary winding is cut off, thereby preventing the positive characteristic thermistor from running away thermally, to be high in temperature and low in resistance, and breading down insulation by flow of excessive current through the auxiliary winding.

In embodiment 22, the snap action bimetal is set so that it may not reset at ordinary temperature. Hence, thermal runaway of positive characteristic thermistor by reset by snap action

bimetal can be prevented completely.

In embodiment 23, the starter of single-phase induction motor, wherein the contact point of the slow action bimetal and contact point of the snap action bimetal directly contact with each other,

when the slow action bimetal reaches the set temperature, it is departed from the contact point at the snap action bimetal side, and

when the snap action bimetal reaches the specified high temperature, it is departed from the slow action bimetal side. When the slow action bimetal is cut off by application of heat, heat is also applied to the snap action bimetal side, and it is slightly moved to the side departing from the slow action bimetal side, and by using a slow action bimetal slow in action though long in life, the starting current can be cut off appropriately. That is, along with temperature rise, both bimetals move in mutually departing direction, and chattering hardly occurs. Further, since both contacts are made of movable contacts, wiping (rubbing) phenomenon always occurs by temperature changes, the contact contacting portions are cleaned, and a long life is realized by using silver contact without gold plating. Further, since the contact points of slow action bimetal and contact points of snap action bimetal directly contact with each other, lower cost and lower resistance are realized as compared with the case of interposing terminal members of metal plates or the like providing fixed contacts at both sides.

In embodiment 24, a stopper is provided to contact with the leading end of the snap action bimetal, so as not to interrupt the operation of the slow action bimetal. It is hence possible to prevent warping to the slow action bimetal side if the snap action bimetal returns to ordinary temperature due to cooling

of positive characteristic thermistor after completion of starting."

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 (A) is an explanatory diagram showing mounting of starter and overload relay on compressor in the first embodiment, FIG. 1 (B) is a perspective view of pin terminal.

FIG. 2 is a circuit diagram of starter and overload relay in the first embodiment.

FIG. 3 is a plan view of starter and overload relay in the first embodiment.

FIG. 4 (A), FIG. 4 (B) are X-X longitudinal sectional views of cover mounting state of overload relay shown in FIG. 3, specifically FIG. 4 (A) showing a state before inversion of bimetal, FIG. 4 (B) showing a state after inversion of bimetal.

FIG. 5 (A) is a bottom view removing bottom cover of starter of single-phase induction motor of the first embodiment of the invention, FIG. 5 (B) is a sectional view of B1-B1 in FIG. 5 (A), and FIG. 5 (C) is a sectional view of C1-C1 in FIG. 5 (B).

FIG. 6 (A) is a plan view from arrow e-side of FIG. 5 (B), FIG. 6 (B) is a side view from arrow f-side in FIG. 5 (C), and FIG. 6 (C) is a bottom view from arrow g-side in FIG. 5 (B).

FIG. 7 (A) is a plan view of assembled state of overload relay in starter, FIG. 7 (B) is a side view, and FIG. 7 (C) is a bottom view.

FIG. 8 (A) is a plan view of snap action bimetal, and FIG. 8 (B), FIG. 8 (C) are magnified sectional views of starter shown in FIG. 5 (C).

FIG. 9 (A) is a magnified view of first connection plate shown in FIG. 5 (A), FIG. 9 (B) is an arrow h-view of FIG. 9 (A), FIG. 9 (C) is an arrow j-view of FIG. 9 (A), and FIG. 9 (D) is a magnified perspective view of abutting portion with main PTC surrounded by circle D in FIG. 9 (C).

FIG. 10 (A) is a plan view of snap action bimetal in a modified example of the first embodiment, and FIG. 10 (B) and FIG. 10 (C) are sectional views of starter in the modified example of the first embodiment.

FIG. 11 (A) is a magnified view of first connection plate in a modified example of the first embodiment, FIG. 11 (B) is an arrow h-view of FIG. 11 (A), FIG. 11 (C) is an arrow j-view of FIG. 11 (A), and FIG. 11 (D) is a magnified perspective view of abutting portion with main PTC surrounded by circle D in FIG. 11 (C).

FIG. 12 (A) is a plan view of snap action bimetal of starter in the second embodiment, FIG. 12 (B) is a side view, FIG. 12 (C) is a plan view of snap action bimetal of starter in other example of the second embodiment, FIG. 12 (D) is a side view of other example, and FIG. 12 (E) and FIG. 12 (F) are explanatory diagrams of operation of snap action bimetal of the second embodiment.

FIG. 13 (A) is a plan view of snap action bimetal of starter in a modified example of the second embodiment, FIG. 13 (B) is a side view, and FIG. 13 (C) and FIG. 13 (D) are explanatory diagrams of operation of snap action bimetal in the modified example of the second embodiment.

FIG. 14 (A) and FIG. 14 (B) are explanatory diagrams of operation of bimetal of starter in the third embodiment.

FIG. 15 (A) and FIG. 15 (B) are explanatory diagrams of operation of switch of starter in the fourth embodiment.

FIG. 16 is an explanatory diagram of reed switch of starter in the fifth embodiment.

FIG. 17 (A), FIG. 17 (B), and FIG. 17 (C) are circuit diagrams of application examples of starter in this embodiment.

FIG. 18 (A) is a magnified perspective view of abutting portion surrounded by circle E in FIG. 5 (B), FIG. 18 (B) is a sectional view B3-B3 in FIG. 18 (A), FIG. 18 (C) is a sectional

view C3-C3 in FIG. 18 (A) (with the inner side from the pin center being cut off), and FIG. 18 (D) is a perspective view of socket terminal of the pin inserted state.

FIG. 19 (A) is a plan view of terminal shown in FIG. 18 (A), FIG. 19 (B) is a sectional view B4-B4 in FIG. 19 (A), and FIG. 19 (C) is an arrow k-view of FIG. 19 (A).

FIG. 20 (A) is a plan view of terminal of the second embodiment, FIG. 20 (B) is a sectional view B4-B4 in FIG. 20 (A), and FIG. 20 (C) is an arrow k-view of FIG. 20 (A).

FIG. 21 (A) is a plan view of terminal of the third embodiment, FIG. 21 (B) is a sectional view B4-B4 in FIG. 21 (A), and FIG. 21 (C) is an arrow k-view of FIG. 21 (A).

FIG. 22 is a graph comparing insertion force of socket terminal in the first embodiment with socket terminal in prior art.

FIG. 23 (B) is a plan view with the lid removed of starter in the sixth embodiment of the invention, FIG. 23 (A) is a sectional view A-A in FIG. 23 (B), and FIG. 23 (C) is a sectional view C-C in FIG. 23 (B).

FIG. 24 (A) and FIG. 24 (B) are side views of starter in the sixth embodiment.

FIG. 25 (B) is a plan view with the lid removed of starter in the seventh embodiment of the invention, FIG. 25 (A) is a sectional view A-A in FIG.25 (B), and FIG. 25 (C) is a sectional view C-C in FIG. 25 (B).

FIG. 26 is a circuit diagram of starter in the seventh embodiment.

FIG. 27 (A) is a circuit diagram of starter in prior art, and FIG. 27 (B) is a circuit diagram of starter disclosed in prior art Japanese unexamined patent publication No. H6-38467.

FIGs. 28 (A)-(G) are prior art. FIG. 28 (A) is a plan view of socket terminal, FIG. 28 (B) is a sectional view, FIG. 28 (C) is a bottom view, FIG. 28 (D) and FIG. 28 (E) are sectional views

showing connection pin inserted state into the starter, and FIG. 28 (F) and FIG. 28 (G) are perspective view showing connection pin inserted state into socket terminal.

BEST MODE FOR CARRYING OUT THE INVENTION

[First embodiment]

Referring now to the drawings, the starter and overload relay of the first embodiment of the invention are explained below.

As shown in FIG. 1 (A), starter 10 and overload relay 50 of the first embodiment are integrally attached to pin terminal 110 of dome 104 of compressor 102, and protected with cover 106. Motor 100 is accommodated in the compressor 102.

FIG 2 is a circuit diagram of starter and overload relay 50 of single-phase induction motor in the first embodiment. Power source terminals 92, 94 are connected to 100 V single-phase alternating-current power source 90, and one power source terminal 92 is connected to power line 96 in series to operation switch 97 and overload relay 50, and other power source terminal 94 is connected to power line 98. Overload relay 50 comprises bimetal 70 and heater 76 for heating bimetal 70, and when single-phase induction motor 100 is overloaded, heater 76 is heated and bimetal 70 cuts off the current. When the temperature is lowered to ordinary temperature by interruption of current, bimetal 70 resets automatically, and current flow is resumed.

Single-phase induction motor 100 includes main winding M and auxiliary winding S, main winding M is connected between power lines 96 and 98, and one terminal of auxiliary winding S is connected to power line 96. Single-phase induction motor 100 is designed to drive enclosed compressor 102, for example, by referring to refrigeration cycle in refrigerator as shown in Fig. 1. Operation switch 97 is turned on or off by temperature control device not shown in the diagram. It is turned on when the refrigerator compartment temperature reaches an upper limit, and

is turned off when lowered to lower limit temperature.

Other terminal of auxiliary winding S is connected to power line 98 by way of a series circuit of positive characteristic thermistor (main PTC) 12 and normally-closed snap action bimetal 18. Parallel to main PTC 12 and snap action bimetal 18, auxiliary positive characteristic thermistor (auxiliary PTC) 14 is connected. Main PTC 12 and auxiliary PTC 14 are composed, for example, of oxide semiconductor ceramic mainly made of barium titanate, in which material, the electrical resistance substantially increases when the temperature goes higher than the curie temperature. For example, positive characteristic thermistor 12 is about 5 ohms at ordinary temperature (around 25 deg. C), about 0.1 kohm at 120 deg. C, and about 1 to 10 kohms at 140 deg. C. Auxiliary PTC 14 has higher resistance values than main PTC 12, and the thermal capacity is set at about 1/3 to 1/10 (optimally about 1/6) so that the power consumption may be 1/3 to 1/10 of main PTC 12. Snap action bimetal 18 senses the generated heat of auxiliary PTC 14, and is turned on or off, and, for example, it is designed to be turned off when the detected heat reaches the set temperature of 140 deg. C.

The operation of starter 10 in the first embodiment is explained. When operation switch 97 is turned on, a starting current flows through main winding M by way of operation switch 97 and overload relay 50. Since main PTC 12 is low in resistance (for example, about 5 ohms) at ordinary temperature, and starting current flows in both series circuit of auxiliary winding S, main PTC 12, and snap action bimetal 18, and parallel circuit of auxiliary PTC 14, thereby the single-phase induction motor 100 is started up.

When starting current of auxiliary winding S flows into main PTC 12, thereby main PTC 12 and auxiliary PTC 14 generate heat, and the electrical resistance increases rapidly. Several seconds later, main PTC 12 and auxiliary PTC 14 reach the

temperature of 140 deg. C, and the electrical resistance of main PTC 12 at this time increases to, for example, 1 to 10 kohms, thereby the current flowing in snap action bimetal 18 decreases. When auxiliary PTC 14 reaches the temperature of 140 deg. C, snap action bimetal 18 is turned off, and no current flows into the series circuit of main PTC 12 and snap action bimetal 18, thereby the single-phase induction motor 100 is started up completely, and gets into stationary operation.

When snap action bimetal 18 is turned off, current flows only into auxiliary PTC 14 side, and heat is generated at auxiliary PTC 14 side, thereby snap action bimetal 18 is kept in OFF state.

Therefore, during stationary operation of single-phase induction motor 100, no current flows into main PTC 12, instead, current flows into auxiliary PTC 14 side. However, the current flowing in auxiliary PTC 14 side is very small only enough to generate heat for keeping the OFF state of snap action bimetal 18, therefore, the power consumption by auxiliary PTC 14 is extremely small comparing with the power consumption by the conventional positive characteristic thermistor.

During stationary operation of single-phase induction motor 100, main PTC 12 of large thermal capacity is cooled to ordinary temperature. On the other hand, since auxiliary PTC 14 is small in thermal capacity it is hence quick to cool. Therefore, if attempted to start again right after stopping single-phase induction motor 100, since auxiliary PTC 14 is quickly cooled nearly to ordinary temperature, and it is ready to restart in about several seconds to dozens of seconds, it is started quickly without repeating operation and reset of overload relay as in the prior art.

Continuously, the mechanical structure of overload relay 50 in the first embodiment is explained by referring to FIG. 3 and FIG. 4.

FIG. 3 is a plan view of overload relay 50 with the cover

removed. FIG. 4 is a section view X-X in FIG. 3, with the cover attached. As shown in Fig. 4, overload relay 50 comprises base 52 made of unsaturated polyester, and cover 54 of PBT resin. On the top of overload relay 50, socket terminal 58 is disposed for inserting a pin (not shown) extending from the motor side, and ~~a~~ tab terminal 56, as shown in Fig. 3, is disposed at the side surface extending sideways for inserting power source side receptacle.

The overload relay 50 is composed as shown in Fig. 4 (A), in which bimetal 70 is held between movable contact plate 60 and movable side terminal 74, and heater 76 is disposed beneath bimetal 70. Movable contact plate 60 is disposed above bimetal 70. One end of movable contact plate 60 is welded and fixed to reinforcing plate 78, and movable contact 62 contacting with fixed contact 64 is attached to the free end.

The mechanical structure of overload relay 50 is more specifically described below.

Tab terminal 56 connected to the power source side receptacle is formed as a flat plate as shown in Fig. 3, and connection plate 72 formed in a crank shape is spot-welded to tab terminal 56, and is connected to terminal 76a of heater 76 by way of connection plate 72. Heater 76 is formed of, for example, Ni-Chrome or iron chrome wire wound in a coil form, and is accommodated in recess 52c (see Fig. 4 (A)) formed in base 52. As shown in Fig. 3, other end 76b of heater 76 is connected to reinforcing plate 78 by way of movable side terminal 74. As shown Fig. 4 (A), reinforcing plate 78 is welded to movable side terminal 74, penetrating through hole in movable contact plate 60 and recess in bimetal 70.

Bimetal 70 comprises rectangular snap 70a, and a pair of holder 70b, 70b for holding snap 70a, and snap 70a is formed same as a flat bimetal, and is inverted in curvature (concave and convex relation) at a specified temperature. As shown in Fig. 4 (A),

bimetal 70 has its holders 70b enclosed and fixed between movable contact plate 60 and movable side terminal 74, and snap 70a is supported on columnar support 52a formed in base 52. Around support 52a, the heater is disposed in a coil form in recess 52c, so that the heat generated in heater 76 is efficiently transmitted to bimetal 70.

Bimetal 70 is fixed on holders 70b, and snap 70a is supported on support 52a, and desired characteristic is obtained by assembling only without requiring adjustment. In particular, since holders 70b are smaller than snap 70a, if holders 70b are fixed, the snap characteristic is the same as in the single bimetal of prior art (bimetal not fixed), and required characteristic may be obtained easily.

On the other hand, movable contact plate 60 is made of elastic metal plate, and has movable contact point 62 at free end, and bump 60a contacting with free end 70a' of the bimetal is disposed nearly in the center.

As shown in Fig. 4 (A), movable contact 62 of movable contact plate 60 fixed to reinforcing plate 78 contacts with fixed contact point 64 and fixed contact plate 66 having fixed contact point 64 has its one end 66a fixed to base 52 side as shown in Fig. 4 (A), and other end 66b extended to outside by way of a through-hole or notch (not shown) formed in cover 54. Outside cover 54, other end 66b of fixed contact plate and socket terminal 58 are connected with each other.

As shown in Fig. 4 (B), bump 54a is formed in cover 54 of overload relay 50, and movable contact plate 60 is allowed to oscillate upward. Cover 54 also has an engaging portion 55 for coupling with Starter 10.

Overload relay 50, as shown in Fig. 4 (A), supplies the current from the power source entered through tab terminal 56 to motor M side as movable contact point 62 and fixed contact point 64 contact with each other before bimetal 70 is inverted

(snaps).

When overcurrent flows due to overload of motor M or confinement of rotor, the heat generation in heater 76 increases, and when bimetal 70 reaches a preset temperature (for example, 120 deg. C), it snaps from the convex state to a concave state as shown in Fig. 4 (B), thereby pushing up movable contact plate 60, and the contact of movable contact point 62 and fixed contact point 64 is cut off. As a result, power supply to motor M is stopped, and the motor is protected. By stopping of power supply to motor M, flow of current to hater 76 is stopped, and the temperature of bimetal 70 declines. Reaching a predetermined temperature, snapping to concave state to convex state, as shown in Fig. 4 (A), the contact of movable contact point 62 and fixed contact point 64 is restored by elasticity of movable contact plate 60, and power supply to motor M is resumed.

Continuously, mechanical structure of starter 10 in the first embodiment is explained by referring to FIG. 5 and FIG.6.

FIG. 5 (A) is a bottom view removing bottom cover of starter of single-phase induction motor of the first embodiment of the invention, FIG. 5 (B) is a sectional view of B1-B1 in FIG. 5 (A), and FIG. 5 (C) is a sectional view of C1-C1 in FIG. 5 (B). In addition, FIG. 5 (B) corresponds to a sectional view of B2-B2 in FIG.5 (C). FIG. 6 (A) is a plan view from arrow e side of FIG. 5 (B), FIG. 6 (B) is a side from arrow f-view in FIG. 5 (C), and FIG. 6 (C) is a bottom from arrow g-view in FIG. 5 (B). As shown in FIG. 6 (B), the starter 10 comprises casing 40 and bottom lid 46, and flange 48 is formed so as to install overload relay 50 as shown in FIG. 6, in its outside.

As shown in FIG. 5 (A), the inside of casing 40 has ~~a~~ terminal 22 connected to auxiliary winding S side shown in FIG. 2. Terminal 22 includes integrally tab terminal 22C, socket terminal 22A, and coupler 22B for coupling them. Coupler 22B has first connection plate 26 having spring member 26B for holding main

PTC 12.

As shown in FIG. 5 (C), one end of second connection plate 30 is connected to tab terminal 22C of terminal 22. Spring member 30a at other end of second connection plate 30 applies spring pressure to auxiliary PTC 14 and holds it. Auxiliary PTC 14 contacts with the base of snap action bimetal 18. That is, spring member 30a of second connection plate 30, auxiliary PTC 14, base of snap action bimetal 18, and one end of third connection plate 32 contact with each other adjacently. Other end of third connection plate 32 is connected to tab terminals 24C of terminal 24 for connecting to power line 98 side and main winding M shown in Fig. 2, Terminal 24 has tab terminal 24C and socket terminal 24A.

On the other hand, at the leading end side of snap action bimetal 18, movable contact point 18a is provided, and contacts with fixed contact point 36a of fixed contact plate 36 formed in a crank shape. At the side wall side of casing 40 of movable contact point 18a, stopper 49 is provided for defining the move of movable contact point 18a. Other end of fixed contact plate 36 is connected to fourth connection plate 33, and other end of fourth connection plate 33 is connected to terminal 25 having tab terminal 25C and socket terminal 25A. Terminal 25 is connected to fifth connection plate 34 having spring member 34B for holding main PTC 12. Fifth connection plate 34 is of same member as first connection plate 26.

Snap action bimetal 18 and auxiliary PTC 14 are accommodated in enclosed compartment 44 formed by partition wall 42 provided at the inner side of casing 40. Enclosed compartment 44 has an airtight structure. Second connection plate 30 is surrounding enclosed compartment 44 by way of vent hole 42a provided in the side wall of casing 40, and third connection plate 32 by way of vent hole 42b, and fourth connection plate 33 by way of vent hole 42c.

FIG. 7 (A) is a plan view of assembled state of overload relay 50 in starter 10, FIG. 7 (B) is a side view, and FIG. 7 (C) is a bottom view. It is assembled by engaging flange 48 of starter 10 with coupler 55 of overload relay 50.

In starter 10 in the first embodiment, since snap action bimetal 18 and auxiliary PTC 14 are accommodated in enclosed compartment 44 in casing 40, heat hardly escapes outside, and the OFF state of snap action bimetal 18 can be maintained by a very small power consumption. Further, as the refrigerant of enclosed compressor, flammable gas (hydrocarbon compound of butane or the like) is used, and if the refrigerant leaks, it is contained within the enclosed compartment. This prevents the refrigerant being ignited by the sparks generated from the opening and closing actions of snap action bimetal 18.

Further, since auxiliary PTC 14 is directly contacting with the base of snap action bimetal 18, the heat from auxiliary PTC 14 can be effectively transferred to snap action bimetal 18, and the OFF state of snap action bimetal 18 can be maintained by auxiliary PTC 14 using small power consumption.

Snap action bimetal 18 of starter 10 in the first embodiment is more specifically described below by referring to FIG. 8.

FIG. 8 (A) is a plan view of snap action bimetal 18, and FIG. 8 (B), FIG. 8 (C) are magnified sectional views of starter shown in FIG. 5 (C).

Snap action bimetal 18 comprises movable contact plate 18b for oscillating movable contact point 18a having a rectangular opening formed in the center, bimetal 18c, and ~~a~~ semicircular plate spring 18d interposed between ~~a~~ first support point P1 of movable contact plate 18b, and ~~a~~ second support point P2 of bimetal 18c. The leading end of movable contact plate 18b is divided into two steps, and has two movable contact points 18a.

Plate spring 18d is made of spring member or bimetal, and is installed to maintain movable contact 18b. That is, as shown

in Fig. 8 (B), when second support point P2 is shifted to the leading end side of bimetal 18c at low temperature from the line segment linking support point P3 and first support point P1 of movable contact plate 18b, movable contact plate is forced so that plate spring 18d may press movable contact point 18a to the side of fixed contact point 36a. Accordingly, snap action bimetal 18 is cut off only in the zero state of contact pressure, the contact time of movable contact point 18a and fixed contact point 36a becomes so short that movable contact point 18a and fixed contact point 36a will not be opened or closed by vibration.

On the other hand, as shown in FIG. 8 (C), when second support point P2 is shifted to the leading end side of bimetal 18c at high temperature from the line segment linking support point P3 and first support point P1 of movable contact plate 18b, movable contact plate 18b is forced so that plate spring 18d may move movable contact point 18a from fixed contact point 36a side. That is, from the state shown in FIG. 8 (B), the bimetal 18C is curved upward. When second support point P2 rides on the upper side by surpassing the line segment (dead point) linking support point P3 and first support point P1 of movable point plate 18b, the thrusting force of plate spring 18d is inverted, and snap action bimetal 18 is changed, as shown in Fig. 8 (C), from movable contact point 18a to fixed contact point 36a, so that the contact can be changed quickly. Therefore, an arc position does not continue, which prevents rough contacts or noise. Hence the connection reliability is high, and durable.

The structure of first connection plate 26 is more specifically described below by referring to FIG. 9. FIG. 9 (A) is a magnified view of first connection plate 26 shown in FIG. 5 (A), FIG. 9 (B) is an arrow h-view of FIG. 9 (A), FIG. 9 (C) is an arrow j-view of FIG. 9 (A), and FIG. 9 (D) is a magnified perspective view of abutting portion with main PTC surrounded by circle D in FIG. 9 (C). As mentioned above, fifth connection

plate 34 is of same member as first connection plate 26.

First connection plate 26 is made of a conductive spring material such as plated stainless steel of copper, copper alloy or conductive metal plate. First connection plate 26 comprises connection portion 26A bent in a crank form as shown in FIG. 9 (A), and a pair of spring members 26B bent in U-form in a direction at right angle to the bending direction of connection portion 26A as shown in FIG. 9 (B). Spring members 26B hold main PTC 12 by elastic force, and connect electrically. As shown in FIG. 9(C), spring members 26B have rectangular openings in the center of a pair of rectangular plates extending sideward, and form a pair of U-shapes facing at the opening side, composed of a pair of parallel portions 26c and linking portion 26d linking parallel portions 26c, and the pair of U-shapes are bent in a U-section to the inner side. Near the leading end of parallel portion 26c, by bending and protruding so that linking portion 26d may come to the inner side, contacting corner 26f abutting against main PTC 12 is formed. As shown in FIG. 9 (B), parallel portions 26c have diaphragm 26e for reducing the contact surface area with casing 40 and preventing heat conduction.

Through-hole 26h is formed in the folded portion of spring member 26B side of connection portion 26A. That is, in first connection plate 26, the width of outer circumference (fuse) 26j of through-hole 26 is 0.5 mm or less. When the current of starting winding S flows more than a specified time (for example, 30 seconds), it is designed to melt down by fuse 26j of the outer circumference of through-hole 26h. As a result, if main PTC 12 deteriorates to generate abnormal heat and cause thermal runaway to be nearly in short-circuited state, fuse 26j is melted down by the current, and burning of starting winding S or starter itself may be prevented. In particular, since through-hole 26h is formed in the bent portion, the abutting folding portion has an elasticity, and by keeping an elastic state, re-fusion of the

fused part can be prevented at the time of fusion of fuse 26j.

Further, as shown in FIG. 9 (D), contacting corner 26f bent at an obtuse angle to contact with main PTC 12 of parallel portion 26c has ~~a~~ slot 26g provided parallel to the extending direction of parallel portion 26c. As a result, the contact point of contacting corner 26f with main PTC 12 is doubled, and the entire spring member 26B contacts with main PTC 12 at four positions of contacting corner 26f, which makes in a total of eight positions. In this way, the contact reliability may be enhanced.

Continuously structure of terminal 22 of starter 10 is described by referring to FIG. 18 and FIG. 19.

FIG. 18 (A) is a magnified perspective view of portion surrounded by circle E in FIG. 5 (B), FIG. 18 (B) is a sectional view B3-B3 in FIG. 18 (A), FIG. 18 (C) is a sectional view C3-C3 in FIG. 18 (A) (with the inner side from the pin center being cut off), and FIG. 18 (D) is a perspective view of socket terminal 22 of pin 116 inserted state. FIG. 19 (A) is a plan view of terminal 22 shown in FIG. 18 (A), FIG. 19 (B) is a sectional view B4-B4 in FIG. 19 (A), and FIG. 19 (C) is an arrow k-view of FIG. 19 (A).

Terminal 22 is, like first connection plate 26, made of a conductive spring material such as plated stainless steel of copper, copper alloy or conductive metal plate. As shown in FIG. 19 (A), terminal 22 is integrally formed of tab terminal 22C, socket terminal 22A, and linking portion 22B for linking them. Tab terminal 22C plaits down a pair of plate portions 22k, extending sideways in the axial direction of connection pin to the inner side, and forms a double structure as shown in FIG. 19 (B). Through-hole 22l is pierced in the center of tab terminal 22C. Linking portion 22B is formed like a crank, and ~~a~~ through-hole 22m is pierced in the center.

As shown in FIG. 19 (C), socket terminal 22A folds a pair of plate portion 22d, extending sideward in the axial direction

of connection pin to the inner side, and the leading ends are formed in an arc to be matched with the columnar shape of the connection pin, and the leading ends are departed from each other to form connection pin holder 22e. Connection pin holder 22e is divided into two sections as shown in FIG. 19 (A), into leading end side first position 22g and inner side second position 22h by slit 22f in vertical direction to axial direction of connection pin. At the opposite side of connection pin holder 22e (at the lower side in FIG. 19 (C)), V-groove 22n is formed so as to improve contact with the connection pin. At leading end first position 22g, V-notch 22j is formed. Similarly, at the leading end of V-groove 22n, V-notch 22o is formed.

As shown in FIG. 18 (A), FIG. 18 (B), and FIG. 18 (C), recess 40a for accommodating leading end 116a of connection pin 116 penetrating through connection pin holder 22e is pierced in casing 40 for holding terminal 22.

In FIG. 18 and FIG. 19, socket terminal 22A of terminal 22 is explained, and socket terminal 24A of terminal 24 and socket terminal 58 of overload relay 50 are also in two-section structure. Starter 10 in the first embodiment has overload relay 50 as shown in FIG. 7, and is attached to pin terminal 110 of compressor 102 as shown in FIG. 1 (A). FIG. 1 (B) is a perspective view of pin terminal 110. Pin terminal 110 has three connection pins 112, 114, 116, and socket terminal 58 is connected to connection pin 112, socket terminal 24A is connected to connection pin 114, and socket terminal 22A is connected to connection pin 116.

In starter 10 and overload relay 50 of the first embodiment, connection pin holder 22e of socket terminals 22A, 24A, 58 is divided into two sections, leading end first position 22g and inner side second position 22h. As shown in FIG. 18 (D), when galling force acts in X-direction and/or Y-direction when inserting connection pin 116, spreading is limited to leading end first position 22g of connection pin holder 22e, which can

not extended up to inner side second position 22h. Hence, in second position 22h, since a favorable contact state with the connection pin is maintained, fatigue does not occur, and damage by heating of contact portion is avoided.

The inserting effort required when inserting the connection pin is shown in FIG. 22. The axis of ordinates shows the insertion force, and the axis of abscissas denotes the pin insertion stroke. The chained line represents the insertion force when inserting connection pin 212 into socket terminal 122A of the prior art referring to FIG. 28. The solid line shows the insertion force when inserting connection pin 116 into socket terminal 22A in the first embodiment. Socket terminal 122A of the prior art shown in FIG. 28 (F) must push to spread open entire connection pin holder (formed by folding plates 122d inside into the leading end in an arc so as to match with arc shape of the connection pin) 122e when connection pin 212 is inserted. Hence, a very large force is needed to insert, and the force needs to be maintained.

On the other hand, in socket terminal 22A of the first embodiment, when inserting into the connection pin, first leading end first position 22g is spread, but as compared with connection pin holder 122e of socket terminal 122A of the prior art, it is enough to push open first position 22g of half length in the axial direction, and only about half insertion force is needed. When the leading end of connection pin 116 reaches inner second position 22h (P2 in the diagram), second position 22h begins to spread, but as compared with connection pi holder 122e of socket terminal 122A of the prior art, large force is not needed. In addition, being guided by first position 22g, the applied force acts to insert connection pin 116 vertically and sideway force is not needed. Thus, in socket terminal 22A of the first embodiment, when starting to insert the connection pin, it is enough to spread open only divided leading end first position

22g, and the insertion work is much easier as compared with the prior art which requires to spread the entire connection pin holder.

Socket terminal 22A of the first embodiment is same in size as in the prior art. It saves space and is easy to install.

If there is inclination between connection pin 116 and socket terminal 22A, since leading end first position 22g and inner side second position 22h contact with connection pin 116 independently, and for example if connection pin 116 and socket terminal 22A contact by point, the contact point is doubled, and the connection pin and socket terminal are connected more securely.

Moreover, as mentioned in relation to Fig. 18 (A), in starter 10 of the first embodiment, since recess 40a for holding chamfered leading end 116a of connection pin 116 penetrating through connection pin holder 22e is provided in casing 40, chamfered leading end 116a of the leading end of connection pin 116 is positioned in recess 40a penetrating through connection pin holder 22e. In the prior art shown in FIG. 28 (D), FIG. 28 (E), since chamfered leading end 212a is positioned within connection pin holder 122e, leading end 212a cannot be gripped, and the gripping force on connection pin holder 122e is lowered. By contrast, in the starter of the first embodiment, since leading end 116a of chamfered connection pin 116 is not gripped by connection pin holder 22e, the gripping force of the connection pin 116 in connection pin holder 22e can be increased. In particular, in the first embodiment, the gripping force is lowered by the width of slit 22f shown in FIG. 21 (A). However, by forming ~~a~~ recess 40a, the same gripping force can be obtained as connection pin holder 122e of the same length as in the prior art without slit.

Socket terminal 2A of the first embodiment is set, as shown in Fig 19 (B), slightly larger in diameter $\phi 1$ of leading end first

position 22g of connection pin holder 22e than diameter $\phi 2$ of inner side second position 22h. That means leading end first position 22g of connection pin holder 22e is wider than inner side second position 22h so as to hold connection pin 116 more softly, hence, a smaller force is needed to insert the connection pin. On the other hand, since inner second position 22h is formed narrower, a favorable contact state with connection pin 116 can be held by second position 22h, thus damage by overheating of contact portion is prevented.

[Modified example of first embodiment]

Referring now to FIG. 10 and FIG. 11, the starter in the modified example of the first embodiment is described. FIG. 10 (A) is a plan view of snap action bimetal in a modified example of the first embodiment, FIG. 10 (B) is a sectional view of ON state of snap action bimetal 18 of the starter in modified example of the first embodiment, and FIG. 10 (C) is a sectional view OFF state.

A shown in Fig. 10 (A), in the modified example of the first embodiment, snap action bimetal 18 is composed of one bimetal, comprising movable contact plate 18e having a hole in the center and holding movable contact point 18a, bimetal portion 18f provided in the center of the hole, and plate spring 18d is interposed between first support point P1 of movable contact plate 18e and second support point P2 of bimetal portion 18f. As shown in FIG. 10 (B) and FIG. 10 (C), the operation of snap action bimetal 18 is the same as in the first embodiment shown in FIG. 8 (B) and FIG. 8 (C), and the description is omitted. FIG. 11 shows first connection plate 26 in modified example of the first embodiment. FIG. 11 (A) is a magnified view of first connection plate 26 in a modified example of the first embodiment, FIG. 11 (B) is an arrow h-view of FIG. 11 (A), FIG. 11 (C) is an arrow j-view of FIG. 11 (A), and FIG. 11 (D) is a magnified perspective view of abutting portion with main PTC surrounded

by circle D in FIG. 11 (C).

First connection plate 26 in a modified example of the first embodiment is similar to the first connection plate in the first embodiment mentioned in Fig. 9. In the first embodiment, however, slot 26g was formed in contacting corner 26f parallel to the extending direction of parallel portion 26c. By contrast in the modified example of the first embodiment, as shown in FIG. 11 (D), notch 26m is provided in contacting corner 26f parallel in the extending direction of parallel portion 26c.

In the modified example of the first embodiment, notch 26m is provided in contacting angle 26f bent obtusely for contacting with main PTC 12 of spring member 26B for holding main PTC 12. As a result, the contact point of contacting angle 26f and main PTC 12 is doubled, and the contact reliability is enhanced. Further, the resonance frequency of contacting corner 26f is different between the inside and outside of notch 26m. If main PTC 12 and spring member 26B resonate, and the electrode section of main PTC 12 is hit by spring member 26B, the electrode can be peeled. In the contrary, in the modified example, since the resonance frequency is different between the inside and outside of contacting corner 26f, they do not resonate at the same time, therefore contact portion 26f never hits the main PTC 12, and the electrode of main PTC 12 will not be damaged.

[Second embodiment]

Snap action bimetal 18 of the starter in the second embodiment is explained by referring to FIG. 12.

FIG. 12 (A) is a plan view of snap action bimetal 18 of starter in the second embodiment, and FIG. 12 (B) is a side view. FIG. 12 (C) is a plan view of snap action bimetal 18 of starter in other example of the second embodiment, FIG. 12 (D) is a side view of other example. FIG. 12 (E) is an explanatory diagram of ON state of snap action bimetal 18 of the second embodiment, and FIG. 12 (F) is an explanatory diagram of OFF state.

As shown in FIG. 12 (A), a slot is formed near the center of bimetal of flat plate of snap action bimetal 18, and central portion 18h around the slot is not processed.The two positions of position 18g are processed by drawing at both sides of the slot. FIG. 12 (C) and FIG. 12 (D) are other examples of drawing at position 18g only. As shown in FIG. 12 (E) and FIG. 12 (F), ~~the~~ snap action bimetal 18 forms snap action by drawing process.

In the starter of the second embodiment, since snap action bimetal 18 is made of a bimetal processed by drawing central position 18h, therefore the contact point can be cut off quickly. Therefore, the arc does not continue, and the rough contact or noise does not occur. Connection time after contact pressure becomes zero, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high and durable.

Continuously the structure of terminal 22 of starter 10 in the second embodiment is described by referring to FIG. 20.

FIG. 20 (A) is a plan view of terminal 22 of starter in the second embodiment, FIG. 20 (B) is a sectional view B4-B4 in FIG. 20 (A), and FIG. 20 (C) is an arrow k-view of FIG. 20 (A).

The starter in the second embodiment is same as that of the first embodiment shown in FIG. 5 and FIG. 6. In the first embodiment, however, leading end first position 22g of connection pin holder 22e of socket terminal 22A and inner side second position 22h were equal in length in the connection pin axial direction. In the second embodiment, the length of leading end first position 22g of connection pin holder 22e is formed to be longer than of the length of inner side second position 22h in the connection pin axial direction. Accordingly, the galling force of inserting the connection pin is only received in first position 22g, since the spreading of galling force into second position 22h is arrested. Hence, a favorable contact state with connection pin 116 is maintained at second position 22h, and damage by overheating of connection portion does not occur.

[Modified example of second embodiment]

Referring now to FIG. 13, snap action bimetal 18 of the starter in the modified example of the second embodiment is described. FIG. 13 (A) is a plan view of snap action bimetal 18 of the starter in a modified example of the second embodiment, FIG. 13 (B) is a side view, FIG. 13 (C) is an explanatory view of ON state of snap action bimetal 18 in modified example of the second embodiment, and FIG. 13 (D) is an explanatory view OFF state.

A shown in Fig. 13 (A), snap action bimetal 18 is processed by forming deformation 18i in the center of the plate. As shown in FIG. 13 (C) and FIG. 13 (D), snap action bimetal 18 can realize snap action by forming processing.

For the starter in the modified example of the second embodiment, snap action bimetal 18 is composed of a bimetal processed by forming deformation 18i, and the contact point can be cut off quickly. Therefore, the arc does not continue, and the rough contact or noise does not occur. Connection time after contact pressure becomes zero, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high and durable.

[Third embodiment]

Bimetal 18 of the starter in the third embodiment is explained by referring to FIG. 14.

FIG. 14 (A) is an explanatory diagram of ON state of bimetal 18 of the third embodiment, and FIG. 14 (B) is an explanatory diagram of OFF state of bimetal 18.

Bimetal 18 of the third embodiment comprises, same as in the first and second embodiment, an auxiliary PTC disposed at the base and movable contact point 18a at the free end side. Magnet 23A for applying magnetic force to bimetal 18 in a direction of forcing movable contact point 18a to fixed contact point 36a side is provided adjacently to bimetal 18. Other configuration

is same as in the first embodiment explained in FIG. 1 to FIG. 9, and the explanation is omitted.

In the starter of the third embodiment, bimetal 18 having movable contact point 18a at the free end side is forced to the contact ON side by the magnetic force of magnet 23A. When bimetal 18 is cut off, the magnetic force of the magnet 23A decreases inversely proportional to the square of the distance. Therefore, bimetal 18 has the strongest magnetic force in movable contact point 18a ON state as show in FIG. 14 (A), and after movable contact point 18a leaves as shown in FIG. 14 (B), the magnetic force decreases suddenly, so that movable contact point 18a can be cut off quickly from fixed contact point 36a. Therefore, the arc does not continue, and the rough contact or noise does not occur. Connection time after contact pressure becomes zero, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high and durable.

Continuously the structure of terminal 22 of starter 10 in the third embodiment is described by referring to FIG. 21.

FIG. 21 (A) is a plan view of terminal 22 of starter in the third embodiment, FIG. 21 (B) is a sectional view B4-B4 in FIG. 21 (A), and FIG. 21 (C) is an arrow k-view of FIG. 21 (A).

The starter in the third embodiment is same as that of the first embodiment shown in FIG. 5 and FIG. 6. In the first embodiment, however, leading end first position 22g of connection pin holder 22e of socket terminal 22A and inner side second position 22h were equal in length in the connection pin axial direction. In the third embodiment, the length of the inner side second position 22h of the connection pin holder 22e is formed to be longer than of the length of leading end first position 22g in the connection pin axial direction. Accordingly, by holding connection pin 116 firmly by the second position, 22h, fatigues does not occur, and a favorable contact state with connection pin 116 is maintained, and damage by heating of

connection portion does not occur.

In the third embodiment, V-notch 22p is cut at the leading end of inner side second position 22h of connection pin holder 22e. When inserting into connection pin 116, after the leading end of connection pin 116 passing through leading end first position 22g reaches inner side second position 22h, it is easy to insert into second position 22h side, and the inserting operation is easy.

[Fourth embodiment]

Switch 18 of the starter in the fourth embodiment is explained by referring to FIG. 15.

FIG. 15 (A) is an explanatory diagram of ON state of switch 18 of the fourth embodiment, and FIG. 15 (B) is an explanatory diagram of OFF state of switch 18.

Switch 18 of the fourth embodiment is composed of a magnetic conductive material, and has movable contact point 18a provided at the free end side. Temperature sensing magnet 23B for applying magnetic force to switch 18 in a direction of forcing movable contact point 18a to fixed contact point 36a side is provided immediately above switch 18, and auxiliary PTC is provided adjacently to temperature sensing magnet 23B. Other configuration is same as in the first embodiment explained in FIG. 1 to FIG. 9, and the explanation is omitted.

In the starter of the fourth embodiment, switch 18 made of magnetic conductive member having movable contact point 18a at the free end side of spring plate senses heat from the auxiliary PTC. When the temperature reaches the set temperature, it is forced by the magnetic force of temperature sensing magnet 23B which is demagnetized. That is, at lower temperature than the set temperature as shown in FIG. 15 (A), switch 18 is attracted by the magnetic force of temperature sensing magnet 23B by resisting the elasticity of the spring plate and is turned on. On the other hand, when the temperature reaches the set

temperature as shown in FIG. 15 (B), switch 18 is turned off by the elasticity of the spring plate due to demagnetization of temperature sensing magnet 23B. At this time of turning off, the magnetic force from temperature sensing magnet 23B drops inversely proportional to the square of the distance. Switch 18 receives the strongest magnetic force in the contact ON state. After movable contact point 18b disconnected, the magnetic force decreases rapidly, so that movable contact point 18a can be cut off quickly from fixed contact point 36a. Therefore, the arc does not continue, and the rough contact or noise does not occur. Connection time after contact pressure becomes zero, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high and durable.

[Fifth embodiment]

Reed switch 19 of the starter in the fifth embodiment is explained by referring to FIG. 16.

In the fourth embodiment, switch 18 composed of a magnetic conductive material is used, but in the fifth embodiment, reed switch 19 is used instead of the switch. Temperature sensing magnet 23B for applying a magnetic force to reed switch 19 in a direction of forcing to the contact ON side is provided immediately above reed switch 19, and auxiliary PTC 16 is provided adjacently to temperature sensing magnet 23B. Other configuration is same as in the first embodiment explained in FIG. 1 to FIG. 9, and the explanation is omitted.

In the starter of the fifth embodiment, reed switch 19 senses heat from auxiliary PTC 16. When the temperature reaches the set temperature, it is turned on or off by the magnetic force of temperature sensing magnet 23B which is demagnetized. That is, at lower temperature than the set temperature, reed switch 19 is turned on by the magnetic force of temperature sensing magnet 23B. When the temperature reaches the set temperature, reed switch 19 is turned off by demagnetization of temperature sensing

magnet 23B. At this time, the magnetic force from temperature sensing magnet 23B drops inversely proportional to the square of the distance, and reed switch 19 is cut off quickly. Therefore, the arc does not continue, and the rough contact or noise does not occur. Connection time after contact pressure becomes zero, and the contact is not opened or closed by vibration. Hence the connection reliability of contact is high and durable.

FIG. 17 shows the circuit of the starter 10 of the embodiment. Referring to FIG. 2, not limited to the circuit not using the capacitor, starter 10 of the embodiment can be suitably used when running capacitor C1 is connected parallel to starter 10 as shown in FIG. 17 (A), or when starting capacitor C2 is connected in series to starter 10 as shown in FIG. 17 (B), or when starting capacitor C2 is connected in series to running capacitor C1 parallel to starter 10 as shown in FIG. 17 (C).

[Sixth embodiment]

The sixth embodiment is the same as the first embodiment, and by referring to FIG. 1 to FIG. 7, its explanation is omitted. In the first embodiment, a snap action bimetal is used, but in the sixth embodiment, a slow action bimetal is used. Hereinafter in the sixth and seventh embodiments, part 18 refers to the slow action bimetal.

The operation of starter 10 in the sixth embodiment is explained. When operation switch 97 is turned on, a starting current flows through main winding M by way of operation switch 97 and overload relay 50. Since main PTC 12 is low in resistance (for example, about 5 ohms) at ordinary temperature, and starting current flows in both series circuit of auxiliary winding S, main PTC 12, and slow action bimetal 18, and parallel circuit of auxiliary PTC 14, and thereby single-phase induction motor 100 is started up.

When starting current of auxiliary winding S flows into main PTC 12, main PTC 12 and auxiliary PTC 14 generate heat, and

the electrical resistance increases rapidly. Several seconds later, main PTC 12 and auxiliary PTC 14 reach the temperature of 140 deg. C, and the electrical resistance of main PTC 12 at this time is, for example, 1 to 10 kohms, and the current flowing in slow action bimetal 18 decreases. When auxiliary PTC 14 reaches the temperature of 140 deg. C, slow action bimetal 18 is turned off, and no current flows into the series circuit of main PTC 12 and slow action bimetal 18. Thereby single-phase induction motor 100 is started up completely, and gets into stationary operation.

When slow action bimetal 18 is turned off, current flows only into auxiliary PTC 14 side, and generates heat thereon. Slow action bimetal 18 senses the generated heat, and is kept in OFF state.

Therefore, during stationary operation of single-phase induction motor 100, no current flows into main PTC 12, instead, current flows into auxiliary PTC 14 side. However, the current flowing in auxiliary PTC 14 side is very small only enough to generate heat for keeping the OFF state of slow action bimetal 18, therefore, the power consumption by auxiliary PTC 14 is extremely small comparing with the power consumption by the conventional positive characteristic thermistor. Further, since slow action bimetal is used, as compared with the former snap action bimetal, it can be used for a longer period of time.

During stationary operation of single-phase induction motor 100, main PTC 12 of large thermal capacity is cooled to ordinary temperature. On the other hand, since auxiliary PTC 14 is small in thermal capacity it is hence quick to cool. Therefore, if attempted to start again right after stopping single-phase induction motor 100, since auxiliary PTC 14 is quickly cooled nearly to ordinary temperature, and it is ready to restart in about several seconds to dozens of seconds, it is started quickly without repeating operation and reset of overload

relay as in the prior art.

Continuously mechanical structure of starter 10 of the sixth embodiment is described by referring to FIG. 23 and FIG. 24.

FIG. 23 (B) is a plan view with the lid removed of starter of single-phase induction motor in the sixth embodiment of the invention, FIG. 23 (A) is a sectional view A-A of FIG. 23 (B), and FIG. 23 (C) is a sectional view C-C in FIG. 23 (B). FIG. 24 (A) is arrow e-view of FIG. 23 (B), and FIG. 24 (B) is arrow d-view of FIG. 23 (B). As shown in FIG. 24 (B), starter 10 has casing 40 and ~~a~~ lid 46, and has ~~a~~ flange 48 for mounting overload relay 50 on the outside.

As shown in FIG. 23 (C), inside of casing 40, terminal 22 is provided to be connected to auxiliary winding S side. Terminal 22 is integrally formed of tab terminal 22a, pin terminal 22c, and coupler 22b for linking them. Coupler 22b has first connection plate 26 having spring member 26b for supporting main PTC 12. First connection plate 26 is bent like a crank in the middle, and through-hole 26a is formed in the bent portion to spring member 26b side. That is, first connection plate 26 is narrow at through-hole 26a, and when a large current flows, it is designed to melt down at the outer circumference of through-hole 26a.

One end of second connection plate 30 is connected to spring member 26b. Spring member 30a at other end of second connection plate 30 holds auxiliary PTC 14 by applying spring pressure. Auxiliary PTC 14 contacts with the base of slow action bimetal 18. That is, as shown in FIG. 23 (A) and FIG. 23 (B), spring member 30a of second connection plate 30, auxiliary PTC 14, base of slow action bimetal 18, and one end of third connection plate 32 are connected adjacently to each other. Other end of third connection plate 32 is connected to coupler 24b (see FIG. 23 (A)) of terminal 24 for connecting to power line 98 side and main winding M. Terminal 24 is integrally formed of tab terminal 24a,

pin terminal 24c, and coupler 24b for linking them.

On the other hand, at the leading end of slow action bimetal 18, movable contact point 18a is provided, and contacts with fixed contact point 36a of crank shaped fixed contact plate 36. Other end of fixed contact plate 36 is fixed to second spring 35 for holding main PTC 12.

Slow action bimetal 18 and auxiliary PTC 14 are accommodated in enclosed compartment 44 formed by L-shaped partition wall 42 provided inside of casing 40. Enclosed compartment 44 has an airtight structure. Second connection plate 30 distributed in enclosed compartment 44 by way of through-hole 42a provided in partition wall 42, third connection plate 32, by way of through-hole 42b, and fixed contact plate 36 by way of through-hole 42c.

In starter 10 of the sixth embodiment, since slow action bimetal 18 and auxiliary PTC 14 are accommodated in enclosed compartment 44 in casing 40, heat hardly escapes outside, and the OFF state of slow action bimetal 18 can be maintained by a very small power consumption. Further, as the refrigerant of the enclosed compressor, flammable gas (hydrocarbon compound such as butane) is used. Even if the refrigerant leaks, since it is contained within the enclosed compartment 44, it is not ignited by spark when opening or closing slow action bimetal 18.

Further, since auxiliary PTC 14 directly contacts with the base of slow action bimetal 18, heat from auxiliary PTC 14 can be efficiently transmitted to slow action bimetal 18, and the OFF state of slow action bimetal 18 can be maintained by auxiliary PTC 14 with small power consumption.

[Seventh embodiment]

The seventh embodiment of the invention is explained by referring to FIG. 25 and FIG. 26. FIG. 26 is a circuit diagram of starter in the seventh embodiment.

The circuit configuration of starter 10 of the seventh

embodiment is same as in the starter of the sixth embodiment. However, in the seventh embodiment, a normally closed snap action bimetal 16 for protection from thermal runaway of main PTC 12 is connected in series to main PTC 12 and slow action bimetal 18.

The operation of starter 10 in the seventh embodiment is explained. When operation switch 97 is turned on, a starting current flows through main winding M by way of operation switch 97 and overload relay 50. Since main PTC 12 is low in resistance (for example, about 5 ohms) at ordinary temperature, and starting current flows in both series circuit of auxiliary winding S, main PTC 12, and slow action bimetal 18, and parallel circuit of auxiliary PTC 14, and thereby single-phase induction motor 100 is started up.

When starting current of auxiliary winding S flows into main PTC 12, main PTC 12 and auxiliary PTC 14 generate heat, and the electrical resistance increases rapidly. Therefore, the current flowing in slow action bimetal 18 decreases. When auxiliary PTC 14 reaches 140 deg. C, slow action bimetal 18 detects it and is turned off, and no current flows into series circuit of main PTC 12, snap action bimetal 16, and slow action bimetal 18, thereby finishing the starting procedure of single-phase induction motor 100.

When slow action bimetal 18 is turned off, current flows only into auxiliary PTC 14 side, and generates heat thereon. Slow action bimetal 18 senses the generated heat, and is kept in OFF state.

Therefore, during stationary operation of single-phase induction motor 100, no current flows into main PTC 12, instead current flows into auxiliary PTC 14 side. However, the current flowing in auxiliary PTC 14 side is very small only enough to generate heat for keeping the OFF state of slow action bimetal

18, therefore, the power consumption by auxiliary PTC 14 is extremely small comparing with the power consumption by the conventional positive characteristic thermistor.

During stationary operation of single-phase induction motor 100, main PTC 12 of large thermal capacity is cooled to ordinary temperature. On the other hand, since auxiliary PTC 14 is small in thermal capacity it is hence quick to cool. Therefore, if attempted to start again right after stopping single-phase induction motor 100, since auxiliary PTC 14 is quickly cooled nearly to ordinary temperature, and it is ready to restart in about several seconds to dozens of seconds.

The following is the explanation of the operation in case of abnormal heat generation on main PTC 12 before actuation of slow action bimetal 18 by auxiliary PTC 14.

When main PTC 12 generates abnormal heat to reach a specified high temperature, snap action bimetal 16 is cut off, and current to auxiliary winding S is cut off. As a result, thermal runaway occurs at main PTC 12 and main PTC 12 becomes low in resistance at high temperature, and thus insulation breakdown due to the flow of large current into auxiliary winding S can be prevented. In particular, since snap action bimetal 16 is set so as not to reset at ordinary temperature, and thermal runaway at main PTC 12 can be completely prevented.

The mechanical structure of starter 10 in the seventh embodiment is explained by referring to Fig. 25. The side view of starter 10 of the seventh embodiment is same as in the sixth embodiment shown in FIG. 24. By referring to this diagram, detailed explanation is omitted.

FIG. 25 (B) is a plan view with the lid removed of starter of single-phase induction motor in the sixth embodiment of the invention, FIG. 25 (A) is a sectional view A-A of FIG. 25 (B), and FIG. 25 (C) is a sectional view C-C of FIG. 25 (B). FIG. 24 (A) is an arrow e-view of FIG. 25 (B), and FIG. 24 (B) is an

arrow d-view of FIG. 25 (B).

As shown in FIG. 25 (C), inside of casing 40, terminal 22 connected to auxiliary winding S side shown in FIG. 26 is provided. Terminal 22 is integrally formed of tab terminal 22a, pin terminal 22c, and coupler 22b for linking them. Coupler 22b has first connection plate 26 having spring member 26b for holding main PTC 12. First connection plate 26 has its center bent like a crank, and through-hole 26a is formed in the bent portion to spring member 26b side. That is, first connection plate 26 is narrow at through-hole 26a, and it is designed to melt down at the outer circumference of through-hole 26a when a large current flows.

One end of second connection plate 30 is connected to spring member 26b. Spring member 30a formed at other end of second plate 30 applies a spring pressure to auxiliary PTC 14 and holds it. Auxiliary PTC 14 contacts with the base of slow action bimetal 18. That is, as show in FIG. 25 (A) and FIG. 25 (B), spring member 30a of second connection plate 30, auxiliary PTC 14, base of slow action bimetal 18, and one end of third connection plate 32 are connected adjacently. Other end of third connection plate 32 is connected to coupler 24b (see FIG. 25 (A)) of terminal 24 for connecting to power line 98 side and main winding M shown in FIG. 26. Terminal 24 is integrally formed of tab terminal 24a, pin terminal 24c, and coupler 24b for linking them.

On the other hand, at the leading end of slow action bimetal 18, movable contact point 18a is provided, and contacts with movable contact point 16a of snap action bimetal 16. The base of snap action bimetal 16 is fixed to second spring 35 in order to hold main PTC 12. In casing 40, on the other hand, stopper 51 extending to the leading end of snap action bimetal 16 is provided, and it is configured so that snap action bimetal 16 may not interrupt the operation of slow action bimetal 18.

In starter 10 of the seventh embodiment, movable contact point 18a of slow action bimetal 18 and movable contact point

16a of snap action bimetal 16 directly contact with each other, and when slow action bimetal 18 reaches the set temperature, it is departed from movable contact point 16a of snap action bimetal 16, and when snap action bimetal 16 reaches the specified high temperature, it is departed from movable contact point 18a of slow action bimetal 18 side. When slow action bimetal 18 is cut off by the application of heat, heat is also applied to snap action bimetal 16 side, and is moved slightly to be departed from movable contact point 18a of slow action bimetal 18. Therefore, by using the slow action bimetal which is long in life but slow in action, the starting current can be cut off appropriately. That is, along with the raising temperature, the bimetals depart mutually from each other, therefore chattering hardly occurs. Further, both contacts are made of movable contact points, and wiping (rubbing) phenomenon always occurs when temperature changes. Thereby, the contact portions of movable contact portions 16a, 18a are cleaned. Thus a long life is realized by using silver contacts, instead of gold plating contacts. Since movable contact point 18a of slow action bimetal 18 and movable contact point 16a of snap action bimetal 16 directly contact with each other, lower cost and lower resistance can be realized as compared with the use of interposed terminal member of metal plate having fixed contact points on both.

In starter 10 of the seventh embodiment, having stopper 51 contacting with the leading end of snap action bimetal 16, it is designed not to interrupt the operation of slow action bimetal 18. Hence, after completion of starting, when main PTC 12 is cooled and snap action bimetal 16 returns to ordinary temperature, warping to slow action bimetal 18 side is prevented, and an adequate contact gap can be maintained.

INDUSTRIAL APPLICABILITY

The invention can be applied not only for driving the closed compressor of refrigeration cycle in refrigerator, but also for driving the closed compressor of refrigeration cycle of air conditioner. Further, it can be applied generally in appliances driven by a single-phase induction motor of capacitor starting type or split phase starting type. The invention can be changed and modified within the scope not departing from the true spirit thereof.